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Measuring Student Participation in a Web-based Environment: A Framework for Developing New Tools

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ABSTRACT

Student participation has been found to be a key factor in the success of online distance learning. Instructor feedback is a key element of students' continued engagement, and effective instructors need to establish mechanisms to understand, encourage and judge student participation. This usually requires devoting several hours reviewing, measuring and grading student participation. To better comprehend the methods currently used to measure student participation, an analysis was performed on 100+ documented empirical distance-learning studies. Based on this analysis, this paper reports a participation evaluation classification and develops an integrated participation evaluation framework that aims to help direct future research related to improving an instructor's ability to efficiently understand student participation. The paper also presents an example of a web-based tool that adheres to the framework and was specifically developed to help instructors evaluate on-line discussions.

Keywords

ALN, Distance Learning, Web-Based Education, Information Visualization.

INTRODUCTION

An Asynchronous Learning Network (ALN) is a collection of people that use asynchronous / different location Computer Mediated Communication tools to communicate, collaborate and in general, act as a knowledge repository for the group (Hiltz & Benbunan-Fich, 1997; Schrum & Benson, 2000). These online communities are used in a variety of application areas including:

- *Public discussion boards*: Web sites such as groups.msn.com, groups.yahoo.com and internet newsgroups are widely used to ask questions and share information on a wide range of topics.
- *Corporate knowledge repositories*: Communities of practice are used within and across firms to capture and share information (Majchrzak, Rice, King, Malhotra & Ba, 2000). Discussion boards, or ALNs, can be key tool used to capture and share that knowledge.
- *Online learning*: Distance courses have been the most common application of ALNs (Hiltz & Turoff, 2002). The growth of online learning is compelling. For example, the current usage of online classes is triple the usage in 1998 (Galt, 2001).

While many of the challenges in using online discussion forums are common across these different application areas, this paper focuses on the use of web-based discussion forums within an online learning context – first describing the importance of student participation, then describing a framework for measuring participation and finally, describing a tool that implements the participation evaluation framework.

Importance of active student participation

Over the years, much has been written about the effectiveness (or lack of effectiveness) of distance/online learning. There is a consistent theme reported, that, for students to get the most out of online learning, students need to be active participants within the course, or more specifically, within the web conference (Achtemeier, Morris, & Finnegan, 2003; Brown, 1997;

Piccoli, Ahmad, and Ives, 2001; Ragan 1999; Shea, Fredericksen, Pickett, Pelz, and Swan, 2001; Spiceland & Hawkins, 2003). To ensure all students are active participants, many instructors require class participation (Sener, 2001; Schrum & Hong, 2002; Spiceland & Hawkins, 2003). Requiring class participation is supported by findings that show that requiring student participation creates a better on-line learning environment (Aviv, Erlich, and Geva, 2003). In a related finding, a strong correlation has been found between an instructor's requirement for discussion and a student's perceived learning (Jiang & Ting, 2000).

The current findings on the importance of participation have been summarized as, "when students are actively involved in collaborative (group) learning on-line, the outcomes can be as good as or better than those for traditional classes. When individuals are simply receiving posted material and sending back individual work, the results are poorer than in traditional classrooms" (Hiltz, 2000). Furthermore, Hiltz (2002) reviewed nineteen studies comparing ALNs with traditional F2F classes. The studies used measures ranging from objective grades to subjective surveys. Hiltz reported that the "evidence is overwhelming that ALNs tend to be as effective or more effective than traditional modes of course delivery".

Student participation paradigms

It has been found that online students collaborate more if instructors provide more structure/guidance (Diaz & Cartnal, 1999). This is partly because some students will try to avoid posting and also because students do not always have a realistic understanding of their actual level of participation. For example, in student surveys, students with a low number of postings report a higher number of postings than they actually contributed, and conversely, students with a high level of interaction reported fewer postings than they actual made (Picciano, 2002). In short, Picciano found that "student perceptions of their interaction in a course need to be viewed with a bit of caution".

There are two forms of structure that instructors can provide. First, one can provide a framework for how a student should interact with the class. Most of these frameworks can be thought of as a form of the 'Digital Socrates' method of instruction (Coppola, Hiltz, and Rotter, 2002). For example, Ehrmann and Collins (2001) describe a 'best-practice' interaction paradigm – the Delphi method. This interaction paradigm consists of each week, each student (1) posts a question, (2) responds to another question, and (3) comments on another response. The second form of structure that an instructor can provide is the way one measures and provides feedback to students on their participation. Some instructors provide that structure through class participation grades and others try to give more qualitative feedback to students.

CLASSIFICATION OF STUDENT PARTICIPATION

In comparing the results of different teacher-student distance learning-based interaction paradigms, Vinaja & Raisinghani (2001) measured the participation using the number of messages posted and the number of messages read. There was no effort to review/quantify the quality of the postings, nor the impact the postings had on other students. While "number of messages" is a possible measurement of student participation, when an instructor requires student postings, one must be careful to avoid giving credit to a student for posting simple comments with little value. In other words, as noted by Jaffe (1997), in order to achieve a good grade, some students will generate "superficial and non-substantive" postings.

Analysis of published DL-based studies

To better understand the methods currently used to measure student participation, an analysis was performed on the reported distance-learning experiments / field studies in the 100+ studies documented in the knowledge repository at www.alnresearch.org (Zhang & Hiltz, 2003). This knowledge base aims to include all published empirical studies of ALN that meet a minimal set of conditions (e.g., present results, include at least 20 subjects). In addition to "counting messages", six other participation evaluation methods have been identified. Table 1 describes these seven participation evaluation methods as well as the number of studies using each method.

Participation Evaluation Method	Description	Number of articles*
Student Survey	Ask students for perceived level of participation (of themselves or other students)	34
Count Messages	Number of messages written by each student	19
Count Replies	Number of replies received from other students (for a student)	3
Log File Analysis	Evaluate log files from the computer conferencing system	7
Coding	Content Analysis using expert Judges	11
Observation	Case or field study with observations from researcher	9
Advanced	Methods such as content analysis, network analysis, visualization	1

Table 1: Reviewing articles reporting results on ALN experiments/studies as identified by www.alnresearch.org
*An article can use more than one method

While the majority of DL-based studies did not mention how to measure or understand student participation, the two methods most commonly used to understand participation were *counting messages* and *student surveys*. As has been discussed previously, both have inherent challenges. When counting messages, one will count / value superficial messages (Jaffe 1997). When using student surveys, one can obtain biases in that students with a low number of postings report a higher number of postings than they actually contributed, and students with a high level of interaction report fewer postings than they actual contributed (Picciano, 2002).

Another participation evaluation method, *content analysis*, was used by five studies and does provide an accurate means to understand student participation. In fact, if an instructor wants to understand a student's participation in the class, they typically need to do content analysis of each student's postings. For example, Lazarus describes grading criteria that includes initiating a new (relevant) topic, posting to a topic more than once, using personal/professional experiences as examples, and responding to/extending another classmate's message in a way that carries the concept a step further (Lazarus 2003).

However, without tools to help an instructor monitor, respond to and grade student postings, the impact on instructor workload when using an ALN can be significant. For example, Lazarus reported that when teaching an online class, participation in discussion groups and grading student postings takes more than 50% of the instructor time total time to teach the class. This time commitment can be demonstrated in the following example – if there are 25 students in a class, and each student posts 5 messages/week, then the instructor must read 125 postings/week (assuming the instructor reads all the student postings). If it takes, on average, 2 minutes to read each message (some postings are long, and some require the instructor to respond to the message), then it will take 250 minutes/week (4.1 hours/week). The demand on instructors teaching online courses has been noted in many articles, and was summarized by Crumpacker (2001), who provided an overview of the literature related to this topic. In one extreme case, professors reported spending 40-60 hours per week for a 2 hour class (Schrum & Benson, 2000). Therefore, it is critical that methods and tools for enhancing instructor's evaluation approaches to grading online student participation are identified, as discussed in the remainder of the paper.

PREVIOUS RESEARCH ON ADVANCED PARTICIPATION EVALUATION METHODS

There have been some tools created to try to help instructors understand class participation. Perhaps the two most relevant examples are Reffray's Distance Learning Management System (Reffay & Chanier, 2002; Raffay & Chanier, 2003) and Ramani's visualizations allowing an instructor to easily see student participation within a DL class (Ramani & Rocha, 2000).

Reffray & Chanier's Distance Learning Management System

Reffay & Chanier (2002; 2003) discussed a Distance Learning Management System (DLMS) to decrease the workload of the instructor (when teaching a distance learning class). The analysis was done on a class of 40 students (divided into 4 sections), during a professional development course on "French as a foreign language". It was suggested that the system could show the structure of learning groups – and help identify problems in student interaction (i.e. when a student needs to become more involved).

This work uses Social Network Analysis, which focuses on the relationship between individuals (i.e. the structure of social interaction), as opposed to the individuals and content of the information exchanged between the individuals (Wasserman & Faust, 1994). In particular, using email messages (but ignoring conference postings), Reffay identified clusters and cliques within the DL class. Furthermore, Reffay investigated networks with and without the instructor. As one might expect, the instructor was an active participant in the class, and without the instructor, different/smaller cliques were identified (as compared to doing network analysis with the instructor as part of the class).

Ramani & Rocha's Visualization of Student Participation

Ramani & Rocha (2000) described a tool based on information visualization, which is the transformation of non-spatial or behavioral data into visual images (Tagarden, 1999). Ramani's tools aim to allow an instructor to easily see student participation within a web-based class by using charts and graphs to display student participation during different time periods. The tool aims to allow the instructor to understand, for example, which students were not actively participating in the class. Ramani states that in a face-to-face (F2F) class, it is easy to see if/when a student withdraws from the class (body language, not showing up to class). However, in an online distance course, tools need to be created to allow instructors to easily see which students are withdrawing from the conversation. The visualizations created by Ramani are based on the number of messages, and the replies to those messages. The tools provide a simple way to get a quick understanding of the frequency of student postings. The views within the tool include:

- A *barchart* which shows one bar for each student, the height is the number of messages in the specified time period. The teacher is shown in a different color.
- A *heatmap* (2D grid), with each cell representing a student for a given day. The students vary across y-axis; the different days (ex. for semester or for a month) vary across the x-axis. The cells are color coded by the number of messages, so it is easy to see which students are active posters on a regular basis.
- A *network-graph*, where each node represents a student. An edge exists between two nodes if there was a message between those two students. When a node is selected, that node, and it's edges are highlighted (to show who has interacted with that student).
- A *color-coded table* shows a visualization of the 'reply/nested' structure of conference systems. This is shown in a table where students are up and down the y-axis, and the x-axis represents different message categories. Within a cell (a specific student for a specific topic), one could have one green dot (the posting of a root item) and several red dots (i.e. follow-up postings).

AN INTEGRATED PARTICIPATION EVALUATION FRAMEWORK

While Ramani and Reffay present interesting and potentially useful tools, these tools are not built on a thorough analysis of the instructor's discussion grading workflow. A review of the key steps of the grading process can identify the key features required to improve instructor productivity in guiding participation within a distance learning based course. As a first step, it is helpful to list the key tasks required by an instructor (with respect to guiding online participation). These tasks include:

1. Defining required class interactions
2. Grading student participation
3. Participating in class discussions (i.e. answering questions)
4. Understanding trends in class postings (i.e. making sure a certain discussion is active)

These tasks, while all related, are currently treated as separate activities because the tools available (ex. web conferencing applications) are focused on supporting 'participating in class discussion', but not the other tasks. As a result, these other tasks are often done in an 'ad-hoc, best effort basis' by each instructor. In fact, due to instructor workload / time constraints, some of these tasks are skipped by some instructors for some classes. Figure 1 shows the current sequencing of these related, but separate tasks.

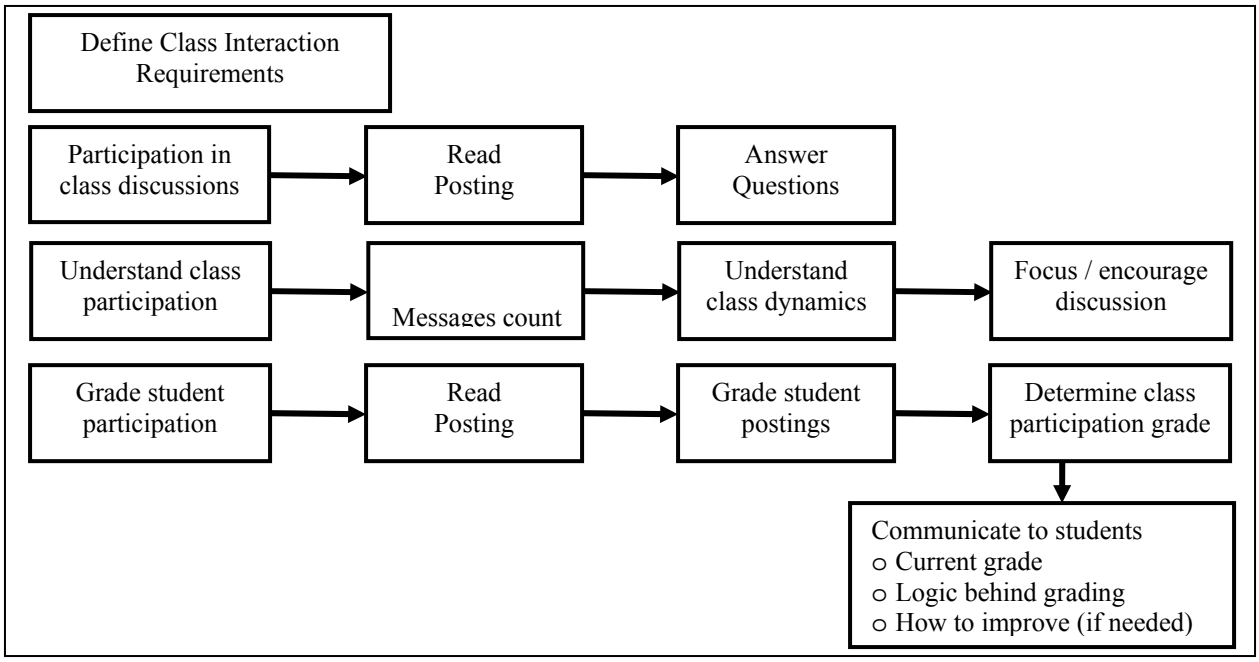

Figure 1: Current instructor participation model grading workflow

By integrating these tasks, instructor time can be optimized (ex. instructors will only need to read a posting once and they could grade discussion within the same environment, rather than maintaining multiple evaluation spreadsheets not collocated with the grading tools). In addition, by providing tools (such as visualizations, network analysis and spreadsheet summaries) to support these integrated activities, instructors can see patterns that are not easily understood by just browsing student postings. Figure 2 shows a new integrated workflow, which represents a comprehensive framework for tool-driven discussion grading. The framework also elicits potential areas for discussion evaluation tool support (i.e. the double-border areas in figure 2). It is hypothesized that a tool suite could be helpful in performing these tasks, and hence increase instructor productivity and the instructor's confidence in the grade given for student participation.

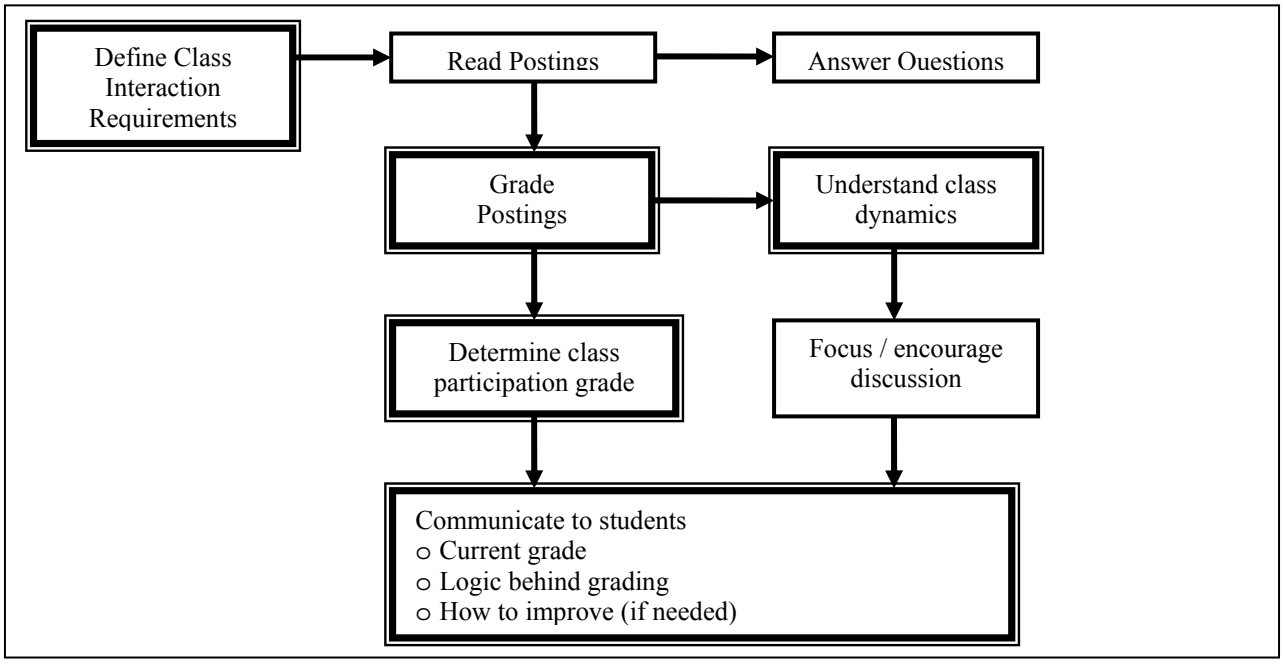

Figure 2: Integrated participation evaluation framework (the double-bordered tasks note which tasks are aided by the discussion system).

CURRENT IMPLEMENTATION OF AN INTEGRATED PARTICIPATION EVALUATION FRAMEWORK

A web-based participation visualization tool, known as the integrated Participation Evaluation Tool (iPET), was built to support the integrated participation evaluation framework. The tool incorporates social network analysis, visualization and a rule-based system to provide modules that aide in the understanding of the whole web conference board, individual student postings and specific conferences. Key features of the application include the ability to easily (1) access a 'quick-grade plug-in' within a web conferencing system, (2) define class participation rules and (3) view class and student details. The tool is implemented using a combination of Java and JavaScript, and can be seamlessly integrated with commercial web conferencing systems.

Grading Module:

A 'quick grade' feature has been implemented so that instructors can easily record a grade for a student posting. When the instructor reads a message, using either a commercial web conferencing system or within iPET, there are a set of buttons displayed for each student posting that the instructor can use to select a grade (and also enter an optional note) for that message. Thus, for any given message, that message will either have a 'not graded' attribute, or one of the following possible grades (A, B, C, or U – unacceptable). Grades can be viewed in many of the class and student views described below.

Rules Module:

One or more participation rules can be defined for a class. The description of the attributes of a rule includes a start date, end date, frequency (ex. once or repeating weekly), required number of messages written by student, required number of messages written by the student as replies to other students, and which conferences (discussion topics) count for posts/replies. For example, an instructor could define a participation requirement rule that specifies that, within a specified time period, students must post a question in a certain conference and comment on three questions that were posted by other students. The system could then determine, for each student, if they participated according to that rule. Comments by students that receive an unacceptable grade would not be counted toward satisfying the rule. The results of the rule analysis are shown in many of the class and student views described below.

Class View Module:

In trying to understand general class participation, for example, to quickly identify students "at risk" due to lack of participation, it is useful to view student participation at the class level, and then 'drill down' to better understand a specific student's participation. The system provides the following views of the class interaction:

- The *weekly by conference* and *weekly by student* views show a heatmap (2D grid). The columns represent different weeks in the semester, and the rows represent either each student or each conference. The number and color in each cell represents the number of messages for that week for the student or conference specified by that row.
- The *student participation plot* shows the impact each student is having within the class by displaying a scatter plot. Each student is positioned in the scatter plot as a function of how many comments were posted by that student and how many comments other students posted in response to comments written by that student.
- The *summary bar chart* view shows a bar chart of student participation. For each student, one can see the number of messages graded as an "A", "B", and so forth represented as a stacked bar chart. In addition, another bar shows the number of replies received by that student (i.e. messages in response to comments written by that student).
- Finally, the *summary data table* shows the participation data within an Excel spreadsheet.

Figure 3 shows a class overview screenshot of the 'weekly by student' view. One can see the activity level for different students ('student 10', for example, is very active in the class). This view does not show student postings that were graded as 'unacceptable'.

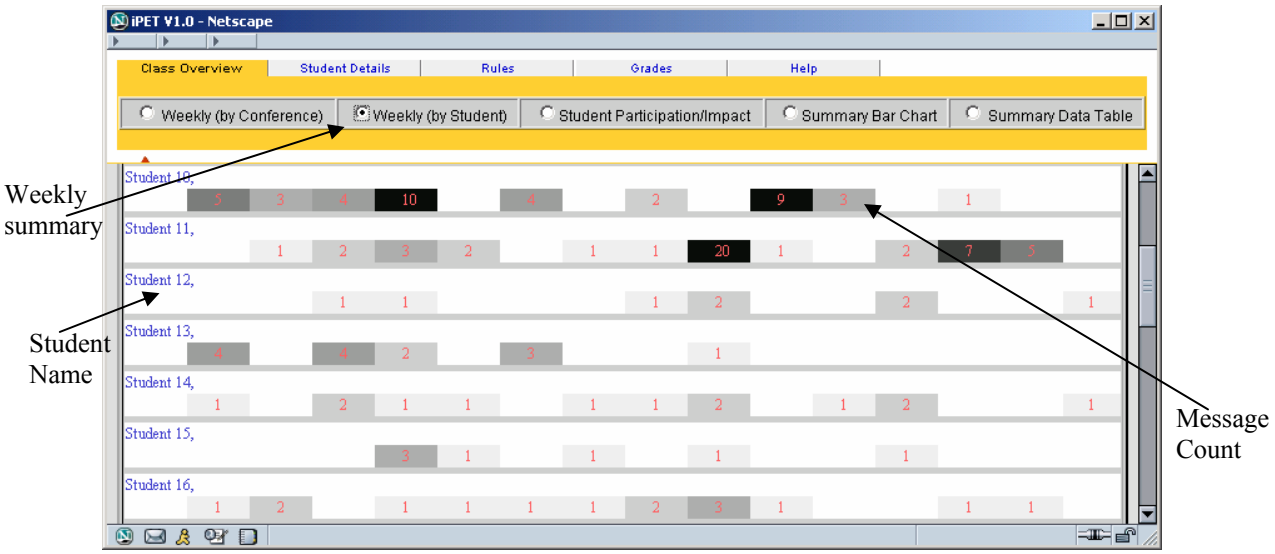

Figure 3: An iPET class view example

Student View Module:

There are three main sections within the student detail view. A list of students is displayed in the *student selection area* (i.e. the left column in the window). These views are similar to those available in the class overview, such as *weekly by student* and *summary barchart*, with the goal of being able to determine which student an instructor wants to view based on participation attributes. Student specific visualizations, described below, are shown in the *Visualization Area* (the upper right part of the window). Finally, the *Message Area* shows the actual text of the student messages (in the lower right part of the window). The message area can show either all of the messages for a student, or a subset that has been selected from the visualization area. The following views are available in the *visualization area* to aide in understand student participation:

- The *summary* displays basic information on the selected student, such as the total number of messages written by the student, and the grade distribution of that student's comments, and the number of messages written by other students in response to this student's messages.
- The *Expandable List* displays a 'folder view' of student postings. For the selected student, one can view a list of all messages written, a list of messages written within each conference or the list of messages written that were used to satisfy a specific rule.
- The *Message Timeline* displays each message written by the student as a rectangle that is positioned along the x-axis as a function of when the message was written. The height of each rectangle represents the number of replies to that message. The messages themselves are color coded based on the grade provided by the instructor ('not graded' is considered one of the grades).
- The *Class Interactions* view shows a person centered clique analysis based upon directed reply links (i.e. student-to-student interactions). In this network view, each node (oval) represents a student. The center oval is the selected student. The size of the oval represents the number of messages written from/to the selected student; and arrows show direction and magnitude of that participation.
- The *Weekly Overview* shows a heatmap (color coded grid of numbers), with a row for each conference, and a column for each week in the semester. The number in each cell (and the color of the cell) represents the number of messages for that week/conference (for that particular student).

In figure 4, the summary bar chart on the left shows total number of messages written by each student (the second bar per student is the total number of messages written by other students as replies to that student). The student visualization shows weekly participation, for the selected student, for each conference within the web conferencing system.

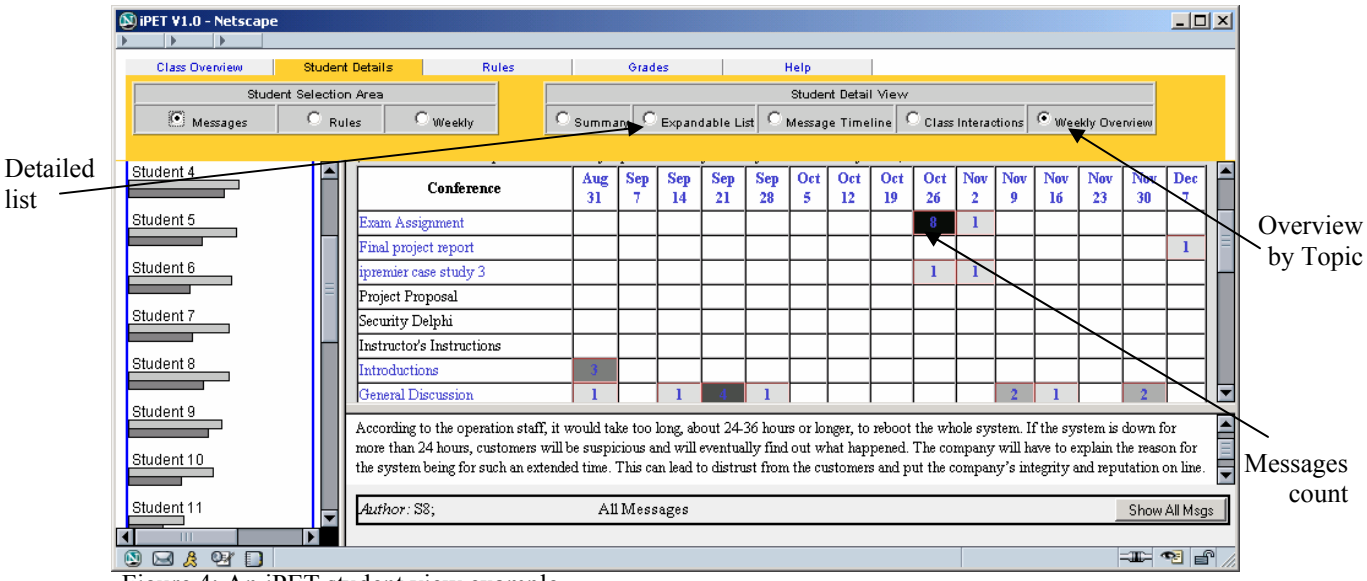

Figure 4: An iPET student view example

USING IPET WITHIN A WEB-BASED DISTANCE COURSE

iPET has been used to implement the streamlined integrated participation evaluation framework that was shown in figure 2. The tasks in which iPET has been used include:

- *Course startup*: During the first few weeks of the semester, instructors need to quickly identify students not actively participating. iPET can be used to quickly identify students not active in the dialog, or just posting contentless postings. The instructor would use this information to reach out (perhaps through email) with those students not participating at the desired quality and quantity.
- *Throughout the course*: During the course, the instructor will be reading and responding to student postings. With the use of iPET, the instructor can quickly add a grade or comment to all, or just a subset of student postings. Since the grading feature is integrated within both the iPET browser and the web conferencing software, the time taken to add these student grades/comments is very small.
- *Semester grading:* At the end of the semester, and perhaps several times during the semester, the instructor needs to determine a class participation grade. iPET can be used to facilitate understanding each students class participation. To determine a class participation grade, the instructor would use any of the grades/comments that they gave to each student. The instructors could view the student postings within any of the student views – most typically either within the message timelines or the expandable list views

In addition, iPET can be used to explore many research questions. For example, since theoretical and applied modules in a course are typically organized in difference conferences (discussion forums), on can look at how the patterns of interaction may differ for these two types of subject matter.

CONTRIBUTION AND FUTURE EFFORTS

In the fall of 2003, the system was piloted within a graduate level Information Systems course. The initial results from this course, and feedback from other instructors, have shown that instructors do have a greater ability to quickly understand student participation, and they also perceive an increase in confidence in the participation grade given to each student. While iPET has been used to support an instructors' grading within in ALN, it can also enable an understanding of the dynamics of student participation. For example it could help answer questions about the role of early visual feedback as a motivating element for future discussion participation. It could also help enable a way to quickly identify leaders (either due to the quality of their answers or due to their influence in creating interesting replies in the class discussion /questions). These leaders might then be leveraged within the class, for example, as designated facilitators within group projects. To better understand how iPET can be used, additional classes are piloting the tool in the spring 2004 semester and a more extensive field study is planned to understand the impact of the framework presented in this paper on instructor productivity and on the students' level and quality of participation.

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